

# *Elephas* cf. *E. planifrons* (Elephantidae, Mammalia) from Upper Siwalik Subgroup of Samba district, Jammu and Kashmir, India

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**Abstract** One specimen of *Elephas* cf. *E. planifrons* is reported and described here in the present paper. The specimen was recovered from the mudstone horizon underlying the volcanic ash bed exposed near the Nangal village, which is the extension of geochronological dated (2.48 Ma) volcanic ash beds exposed at Barakhetar in the Nagrota Formation of Upper Siwalik Subgroup of Samba district, Jammu and Kashmir, India. Based on the crown morphological parameters (plate numbers, molars length and width, crown length, width and height, enamel thickness, dentine thickness, length and width of plates, lamellar frequency, hypsodonty index and cement thickness), the specimen has been identified and is tentatively referred to *Elephas* cf. *E. planifrons* (LM3). The recovery of this specimen is of great significance as it extends its upper limit of range zone from 3.6–2.6 to 3.6–2.48 Ma.

**Key words** Jammu, India; Nagrota Formation, Upper Siwalik Subgroup; *Elephas*

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## 1 History of research

From time to time various authors carried out work on elephants origin, evolution and palaeoecology, taxonomy, distribution, classification, anatomy, ecology, behaviour, phylogenetic analysis and fossil elephantids lineages (Aguirre, 1969; Maglio, 1973; Sarwar, 1977; Tassy, 1983; Shoshani and Tassy, 1996, 2005; Wei et al., 2006; Gheerbrant and Tassy, 2009; Todd, 2010a,b) from the different parts of the world.

In Indian subcontinent, the genus *Elephas* is represented by four species (*E. planifrons*, *E. hysudricus*, *E. namadicus*, and *E. maximus*). In these four species, the first three (*E. planifrons*, *E. hysudricus*, *E. namadicus*) were extinct completely from Indian subcontinent and the last one (*E. maximus*) is surviving till date. Detailed studies on geology, palaeontology, phylogeny and age of the elephantidea fauna (*Steglophodon nathotenis*, *Steglophodon latidens*, *Steglophodon cautleyi*, *Stegodon clifti*, *Stegodon bombifrons*, *Stegodon pinjorensis*,

*Archidiskodon planifrons*, *Elephas hysudricus*, *E. maximus*, *E. hysudrindicus*, *E. planifrons*, *Palaeoloxodon namadicus*) from the Siwalik of India, Pakistan and Burma were carried out by various authors (Osborn, 1942; Sahni and Khan, 1959; Chakravarti, 1965; Opdyke et al., 1979; Azzaroli and Nepoleone, 1981; Badam and Kumar, 1982; Tripathi and Basu, 1983; Nanda et al., 1991; Samiullah et al., 2014).

In Siwalik Province of Jammu, Jammu & Kashmir State, India no detailed work on Elephantidae fauna was carried out except for a few workers (Wadia, 1925; Ganjoo, 1985; Nanda, 1994; Kundal and Kundal, 2011; Sankhyan and Sharma, 2014). Wadia (1925) first time recovered a tusk (about 3.43 m) of *Stegodon ganesa* from near the Jagti village of Nagrota Formation of Upper Siwalik Subgroup of Jammu. Ganjoo (1985) recovered dental remains of *Stegolophodon* sp., *Stegodon insignis*, *Stegodon ganesa* and *Elephas* sp. from the Pleistocene deposits of Khanpur Formation (Pinjor Formation) and Tawi Formation (Boulder Formation) of Upper Siwalik Subgroup of Jammu region. The comment on certain faunal discrepancies on Upper Siwalik mammalian faunas from Chandigarh and Jammu area was given by Nanda (1994). A lot of specimens of proboscidean were collected by the Geological Survey of India from the Siwalik of Jammu and other part of Siwalik of India and these specimens have been published in the Catalogue series no. 5 in the year 2002. An appraisal of diversity and habitats of Siwalik mammals of the Jammu Sub-Himalaya was discussed by Basu (2004). Recently, Kundal and Kundal (2011) recovered an upper right third molar (M3) of *Elephas maximus indicus* from the post Siwalik deposits of Jammu Province near Kharian village, Jammu and Kashmir, India. A few workers (Prasad et al., 2005; Bhat et al., 2008; Bhandari and Kundal, 2008; Kundal and Prasad, 2011; Kundal et al., 2011; Kundal, 2012, 2013, 2015) carried out detailed studies on fossils recovered from mudstone horizons associated with geochronologically dated volcanic ash occurring in Upper Siwalik of Jammu and its depositional environment. In the present study, the systematics and biochronology of *Elephas* cf. *E. planifrons* recovered from the Nangal village of Nagrota Formation, Upper Siwalik Subgroup of Samba district of Jammu and Kashmir has been carried out. The area in this study is given in Fig. 1A.

Geological, palaeontological and palaeomagnetic studies of type sections of Siwalik in Indian subcontinent have been carried out from time to time by various workers (Colbert, 1935; Lewis, 1937; Wadia, 1957; Keller et al., 1977; Opdyke et al., 1979, 1982; Johnson et al., 1982, 1985; Barry et al., 1982, 2002, 2013; Barry and Flynn, 1990; Flynn et al., 1995, 2013; Badgley et al., 2005, 2008; Patnaik, 2013) and revealed that the boundaries are time transgressive in between most of Formations of the Siwalik Group and that temporal mammals ranges are not usually fixed within the time limits of these Formations. A generalized stratigraphic framework of Siwalik in Indian Subcontinent is given in Fig. 1D.

The local classifications of Upper Siwalik Subgroup of Jammu–Samba district of Jammu Province based on palaeontology, magnetostratigraphy and radiometric date of ash beds were given by Ranga Rao et al. (1988), Agarwal et al. (1993) and Gupta (2000). A comparative lithostratigraphic classification of Siwalik Group of Jammu Province in Jammu and Kashmir,

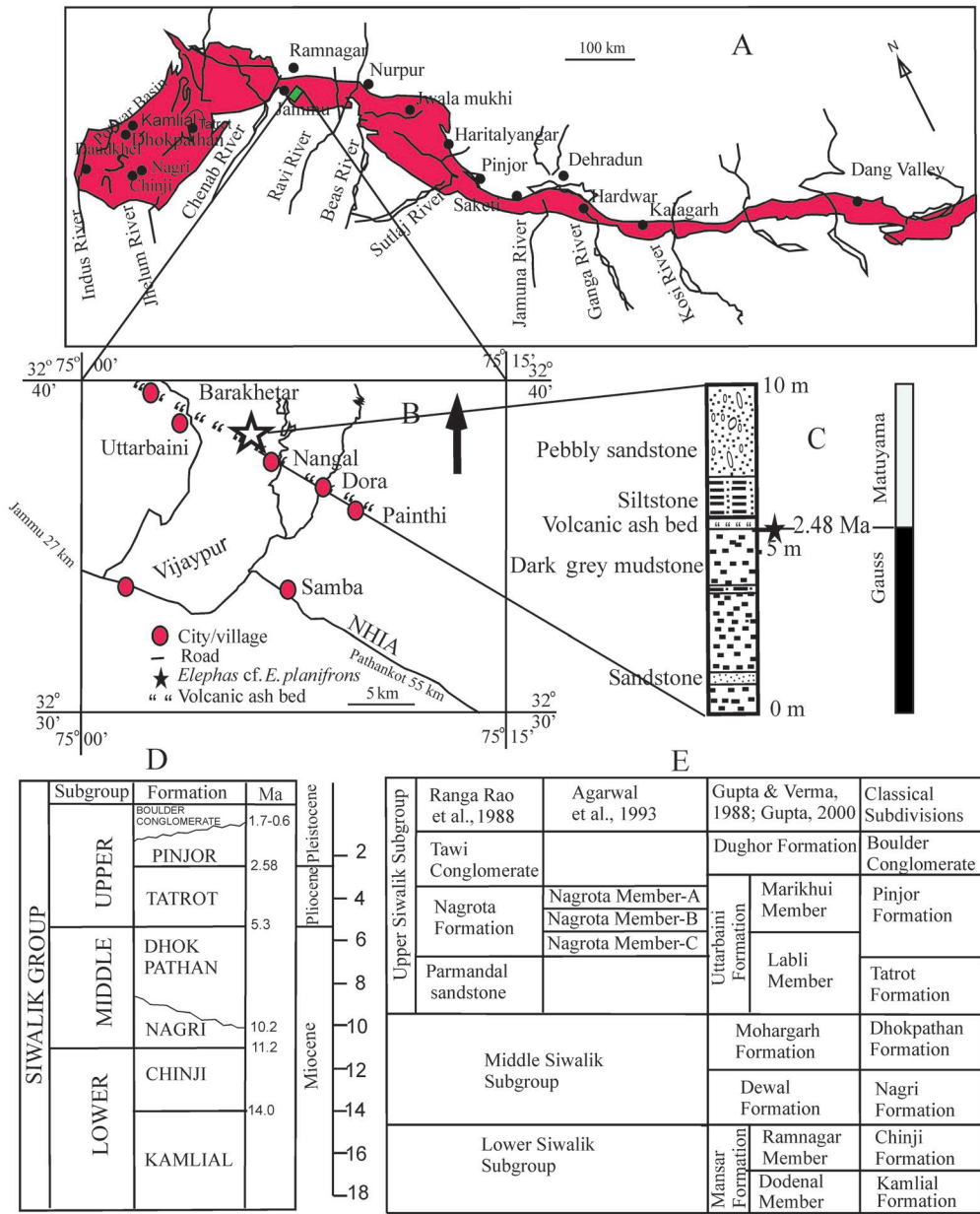


Fig. 1 Map showing range of Siwalik Hills and area under study (small box) (A), locality of *Elephas* cf. *E. planifrons* (B), position of *Elephas* cf. *E. planifrons* in the lithocolumn and the ash bed (2.48 Ma) act as transition between Gauss Normal and Matuyama Reversed Polarity Epochs (C), a generalized stratigraphic framework of the Siwalik sequence (D) (Modified from Behrensmeyer and Barry, 2005; dates from Johnson et al., 1985; Ranga Rao et al., 1988; Barry et al., 2002), and comparative local lithostratigraphic classifications of the Siwalik sequence of Jammu-Samba Region (E)

India is given in Fig. 1E. In Pinjor/Nagrota Formation, a volcanic ash bed is occurring at near Barakheta and Nagrota villages which have been geochronologically dated 2.48 Ma. These ash beds straddle across Gauss-Matuyama boundary in the Siwalik of Jammu-Samba district

of Jammu and Kashmir, India (Ranga Rao et al., 1988). The specimen described in the present study was discovered from the mudstone horizon immediately underlying geochronologically dated 2.48 Ma volcanic ash bed at Nangal village which is the extension of Barakheta ash bed and now is preserved in the vertebrate palaeontology laboratory, Geology Department of Jammu University, under catalog number JU/GD/VPL/9001.

## 2 Systematic palaeontology

### **Class Mammalian Illiger, 1811**

### **Order Proboscidea Gray, 1821**

### **Family Elephantidae Gray, 1821**

### **Genus *Elephas* Linnaeus, 1735**

### ***Elephas* cf. *E. planifrons* Falconer & Cautley, 1845**

(Fig. 2A–C)

**Referred material** JU/GD/VPL/9001, left M3 with broken roots and broken anterior two plates.

**Locality** River cutting section 15 km northwest of Samba city near the village Nangal, J&K, India.

**Stratigraphic horizon** Mudstone horizon underlying volcanic ash bed in Nagrota Formation (Ranga Rao et al., 1988)/Uttarbaini Formation (Gupta and Verma, 1988)/Pinjor Formation (Pilgrim, 1934).

**Age** Late Pliocene–Early Pleistocene.

**Measurements** (in mm) Number of plates, 9 ( $2^{1/2}$  broken out +  $6^{1/2}$  preserved); length of molar, 140+50 (broken anterior two plates); width of molar, 82; length/width ratio, 1.70; number of plates preserved,  $6^{1/2}$  ( $4^{1/2}$  worn + 2 unworn); average length of plates (occlusal), 72; average width of plates (occlusal), 17.16; lamellar frequency (lf), 6; average enamel thickness (et) of worn plates, 3.5; average cement thickness (ct) between plates, 10; average dentine thickness (dt) of worn plates, 4.64; crown length, 140; crown width, 92; maximum crown height, 80; hypsodont index ( $H/W \times 100$ ), 87.

**Description** JU/GD/VPL/9001 has well preserved plates with broken roots. The anterior two and half plates of molar are broken out. The shape of the molar tapers at the posterior end (ovate); molar curvature is straight; inclination of plates to occlusal surface is weak; molar roots are strong and broken; enamel height above the cement is high; enamel figures are parallel sided with median loop, lateral sides of enamel are rounded and turn slightly anteriorly; the enamel are symmetrical in line with the long axis of the molar; medial edges of enamel of two middle plates are in contact, undulating folded; amplitudes of enamel folding in few plates are high to low; and space between enamel folds in few plates are tight to loose. The plates are well compact with cement and are widely spaced. The plates are slightly slanting towards posterior side. The specimen has four and a half worn plates and two unworn

plates. The width of the molar increased from posterior to centre and then decreased slightly towards anterior side. Except the four and half worn plates, three plates have developed strong expansion of loops at the middle which are in connection with the adjacent ones. The enamel layer is quite simple and thick.

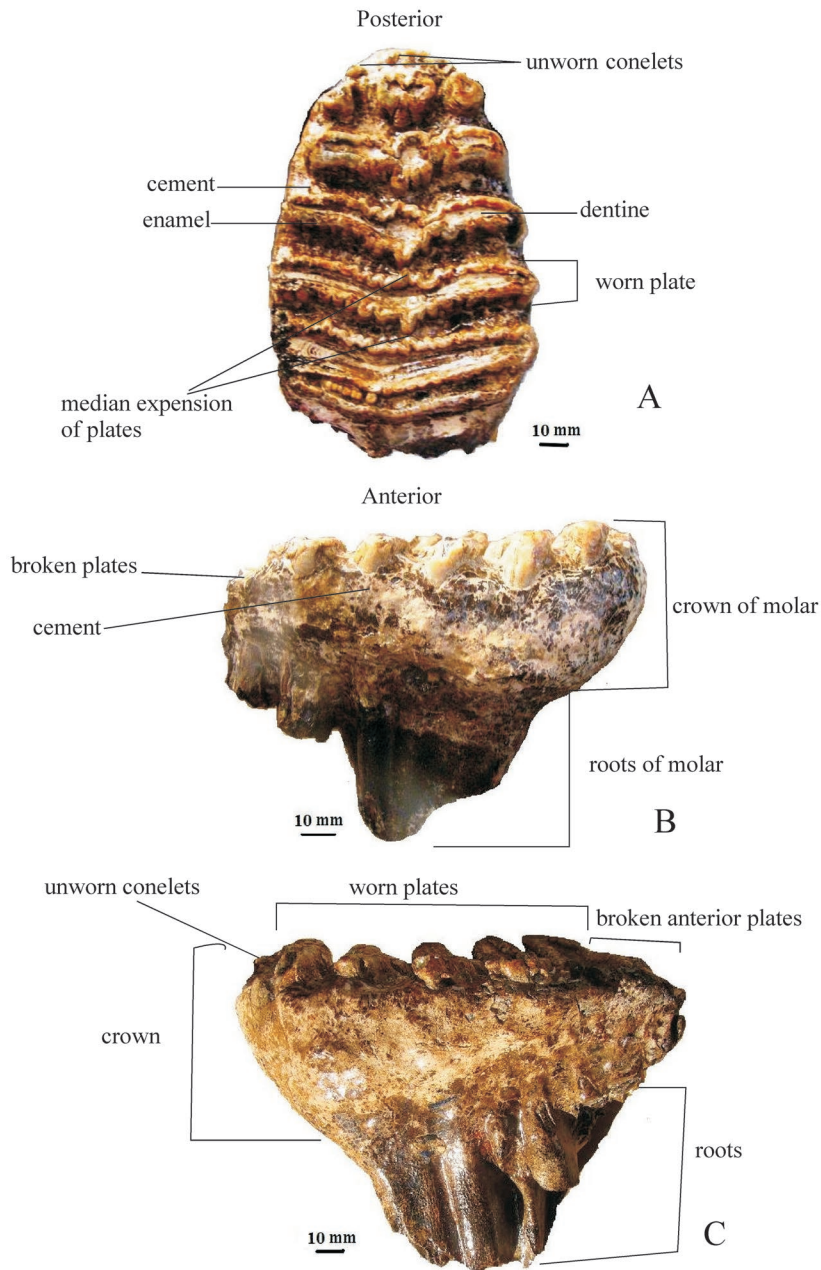


Fig. 2 Left M3 of *Elephas* cf. *E. planifrons*, JU/GD/VPL/9001  
A. occlusal view; B. labial view; C. lingual view



### 3 Comparative study of specimen JU/GD/VPL/9001 with allied species of *Elephas*

By using the dental morphological characters (number of plates, length of molar, height and width of crown, lamellar frequency, enamel thickness and hypsodonty index), the specimen JU/GD/VPL/9001 under study is compared with allied species of *Elephas* (*E. namadicus*, *E. hysudricus*, *E. hysudrindicus*, *E. maximus*, *E. naumani*, and *E. planifrons*) described earlier (Maglio, 1973). The details of parameters described are given in Table 1.

**Table 1 Comparative measurements (observed range and mean) of JU/GD/VPL/9001 with allied species of *Elephas* (M3)**

	<i>E. namadicus</i>	<i>E. hysudricus</i>	<i>E. hysudrindicus</i>	<i>E. maximus</i>	<i>E. naumani</i>	<i>E. planifrons</i>	JU/GD/ VPL/9001
Number of plates	12–16 14.3	12–15 13.5	18–21 19.5	22–27 24.5	17–19 18	8–12 10	$6^{1/2} + 2^{1/2} = 9$
Length of molar	223–317 271.3	235–302 267.2	293.2–316.6 304.9	244–282 271.9	211–278 244.5	201–292 238.2	190
Width of crown	61–101 84	93–107 97.2	72.3–82.5 77.4	80–98 89	81–95 88	86–111 98.7	92
Height of crown	137–218 175.5	108–137.2 125.4	128.4–149.3 138.8	187–214 200.5	195–251 223	76–129 94.2	80
Lamellar frequency	4.5–7.7 5.7	3.9–6.5 5.4	6.5	5–9 7	6–7 6.5	2.6–5.5 4.2	6
Enamel thickness	1.8–3.0 2.4	2.5–4.8 3.2	2.6–2.7 2.6	2.5–3.0 2.75	2.0–3.2 2.6	2.8–4.8 3.9	3.5
Hypsodonty index	135.6–298 212.4	112.5–147 131.1	177.5–182.3 179.9	150–250 200	230–320 275	80–110 97.6	87

*Elephas namadicus* differs from the JU/GD/VPL/9001 in number of plates (12–16), length of molar (223–317), width of crown (61–101), height of crown (137–218), enamel thickness (1.8–3.0) and hypsodonty index (135.6–298). The parallel lophs and absence of median expansion is very characteristic of *E. namadicus* which differentiate it from JU/GD/VPL/9001.

*Elephas hysudricus* differs from JU/GD/VPL/9001 in number of plates (12–15), length of molar (235–302), width of molar (93–107), height of crown (108–137), lamellar frequency (3.9–6.5) and hypsodonty index (112.5–147.2). Lack of median expansion and strong plication of lophs is the characteristic of *E. hysudricus* which is differentiated it from the JU/GD/VPL/9001 (Ganjoo, 1992).

*Elephas hysudrindicus* differs from JU/GD/VPL/9001 in number of plates (18–21), molar length (293.2–316.6), crown width (72.3–82.5), crown height (128.4–149.3), lamellar frequency (6.5), enamel thickness (2.6–2.7) and hypsodonty index (177.5–182.3). *E. hysudrindicus* is the most advanced member of *Palaeoloxodon namadicus* group.

*Elephas maximus* differs from JU/GD/VPL/9001 in number of plates (22–27), molar length (244–282), crown width (80–98), crown height (187–214), lamellar frequency (5–9), enamel thickness (2.5–3.0) and hypsodonty index (150–250). JU/GD/VPL/9001 has anterior and posterior columns along the median line (lenticular) which is absent in the *E. maximus*.

*E. maximus* has narrow folding enamel structure, whereas JU/GD/VPL/9001 has thick folded enamel structures.

The molar characters such as range of hypsodonty index, enamel thickness, lamellar frequency, height of crown, width of crown, length of molar and number of plates of *Elephas naumani* are 230–320, 2.0–3.2, 6–7, 195–251, 81–95, 211–278 and 17–19 respectively, whereas the hypsodonty index, enamel thickness, lamellar frequency, height of crown, width of crown, length of molar and number of plates of JU/GD/VPL/9001 are 87, 3.5, 6, 80, 92, 190 and 9 respectively, which are different from *E. naumani*.

JU/GD/VPL/9001 specimen understudy is broad and brachydont with expanded strong anterior and posterior columns along the median line (lenticular) which are the characteristic features of the *Elephas planifrons* (Osborn, 1942). The average enamel thickness of molar is 3.5 mm which precisely equals to the *E. planifrons* at the Indian Museum, Calcutta. The lamellar frequency of *E. planifrons* given by different authors is, Osborn (1942): up to 6; Hooijer (1955): up to 5; Maglio (1973): 2.6–5.5.

The lamellar frequency of molar under study is 6 and this specimen is also compared with the *Elephas planifrons* collected by Gupta (1981–1982) field session, from the Marikhu Member of Uttarbaini Formation which was published in GSI Catalogue No. 5 (pictorial catalogue of Siwalik vertebrate fossils from NW Himalaya in the year, 2002 (pp.130, figure 1)). JU/GD/VPL/9001 is compared with the most primitive specimen (M3) of *E. planifrons* (number 19965, American Museum) collected by Barnum Brown from Upper Pliocene Pinjor horizon of the Siwalik near the Siswan, India. The specimen resembles with JU/GD/VPL/9001 in outline as well as dental characters such as plate numbers, enamel thickness, molar length, etc. JU/GD/VPL/9001 is also compared with the specimen No. WIF/A 423 (Nanda et al., 1991) which favours *E. planifrons*.

Based on the above comparative studies of parameters such as plate number, lamellar frequency, hypsodonty index, straight molar curvature, greatest height of crown at posterior end, molar shape tapered at posterior end (ovate), thick cement on the sides and valleys, enamel highly crenulated, molar roots strong and broken, high enamel height above the cement, parallel sided with median loops expansion, rounded lateral sides of enamel and symmetrical in line with long axis of molar and discussion, JU/GD/VPL/9001 shows close affinity to *Elephas planifrons* and tentatively referable as *Elephas* cf. *E. planifrons*.

#### 4 Biozones/faunal interval zones

Various biostratigraphic interval zones of Siwalik Group of Pakistan have been recognized based on fauna and lithology and magnetostratigraphy by number of workers (Pilgrim, 1913; Barry et al., 1982; Azzaroli, 1985; Hussain et al., 1992). In India, Verma (1988) recognised two biozones based on his work in the Markanda valley of Himachal Pradesh. These biozones are *Equussivalensis–Elephas hysudricus* (EE) Biozone and *Stegodon insignis–*

*Hipparion theoboldi*–*Hexaprotodon sivalensis* (SHH) Biozone.

The SHH biozone evidently corresponds to the *Hexaprotodon sivalensis* Interval Zone of Potwar Plateau (Pakistan) ranging from 5.3–2.9 Ma B.P. (Barry et al., 1982) and EE biozone corresponds to the *Elephas planifrons* Interval Zone ranging from 2.9–1.5 Ma B.P. and Pinjor Faunal Zone of the type area respectively. The SHH biozone is restricted to the Saketi Formation and exhibits a high frequency of aquatic forms in Himachal Pradesh and EE biozone is characterised by the presence of *Equus*, absence of *Hipparion*, presence of some aquatic forms and terminates at the end of Pinjor Formation.

The range of *Elephas planifrons* Interval Zone was modified by Hussain et al. (1992) from 2.9–1.5 to 3.4–2.7 Ma and also recognised a fifth zone known as *Elephas hysudricus* Range Zone (2.7–? Ma). Later the upper limit of the *E. hysudricus* Range Zone was proposed by Nanda (1997) up to 0.6 Ma based on the fossils available in the Indian Siwalik. The lower limit of *E. planifrons* Interval Zone was modified by Agarwal et al. (1993) and was extended up to 3.6 Ma based on dated *E. planifrons*. Nanda (1997) recognised two biostratigraphic interval zones of the Upper Siwalik Subgroup with their lower and upper limits as: 1) *E. hysudricus* Range Zone (contains most of taxa of Pinjor fauna), 2.6–0.6 Ma; 2) *E. planifrons* Interval Zone (contains most of taxa of Tatrot fauna), 3.6–2.6 Ma.

Based on the presence of fauna in the Pabbi Hills of Upper Siwalik of Pakistan, Dannell et al. (2006) divided the *Elephas hysudricus* Range Zone of Hussain et al. (1992) into *Elephas hysudricus*–*Crocota*–*Ursus*–*Panthera* faunal zone, 1.7–0.9 Ma, and *Elephas hysudricus*–*Sivatherium* faunal zone, 2.7–1.7 Ma.

As the *Elephas* cf. *E. planifrons* in the present study has been recovered from the mudstone horizon underlying geochronologically dated (2.48 Ma) volcanic ash beds (Ranga Rao et al., 1988), the upper limit of range zone of *Elephas planifrons* may be extended from 2.6 (Nanda, 1997) to 2.48 Ma (proposed). The biostratigraphic interval and range zones of the elephant fauna by various authors and proposed range zone of *Elephas planifrons* are given in Fig. 3.

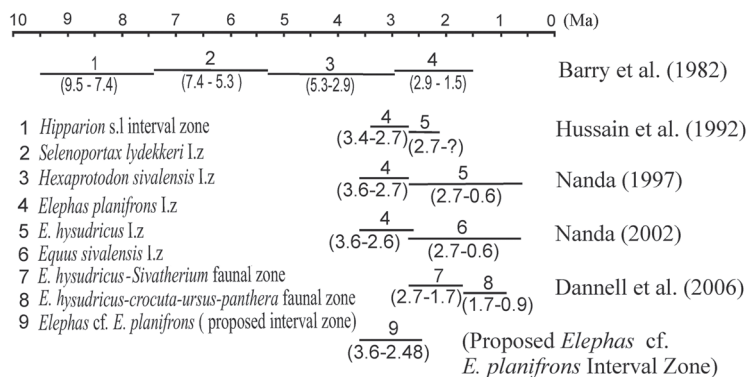


Fig. 3 Faunal interval zones suggested by various authors and proposed *Elephas planifrons* Interval Zone



## 5 Conclusion

The recovery of *Elephas* cf. *E. planifrons* specimen from the mudstone underlying geochronologically dated (2.48 Ma) volcanic ash bed indicates that the age of the specimen is not younger than the volcanic ash beds exposed in the Upper Siwalik Subgroup of Samba districts. The upper limit of the *Elephas* cf. *E. planifrons* Interval Zone is also extended from 2.6 (Nanda, 1997) to 2.48 Ma (proposed) in the present study as the specimen recovered from underlying geochronologically dated ash bed.

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## 查谟-克什米尔桑巴地区上西瓦立克亚群中的平额象化石

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**摘要:** 报道和描述了一件平额象左侧M3化石。新材料产自Nangal村附近火山灰层之下的泥岩层, 该火山灰是出露于查谟-克什米尔桑巴地区Barakhetar上西瓦立克亚群Nagrota组中年龄为2.48 Ma的火山灰层的延伸。根据齿板数, 臼齿长和宽, 齿冠长、宽和高, 釉质和齿质厚度, 齿板长和宽, 齿脊频率, 冠高指数以及白垩质厚度等齿冠形态参数, 暂时将之归为*Elephas* cf. *E. planifrons*。新材料的发现将该种的分布上限从2.6 Ma提高到2.48 Ma。

**关键词:** 印度查谟, 上西瓦立克亚群, Nagrota组, 象类

**中图法分类号:** Q915.878 **文献标识码:** A **文章编号:** 1000-3118(2017)01-0059-12

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